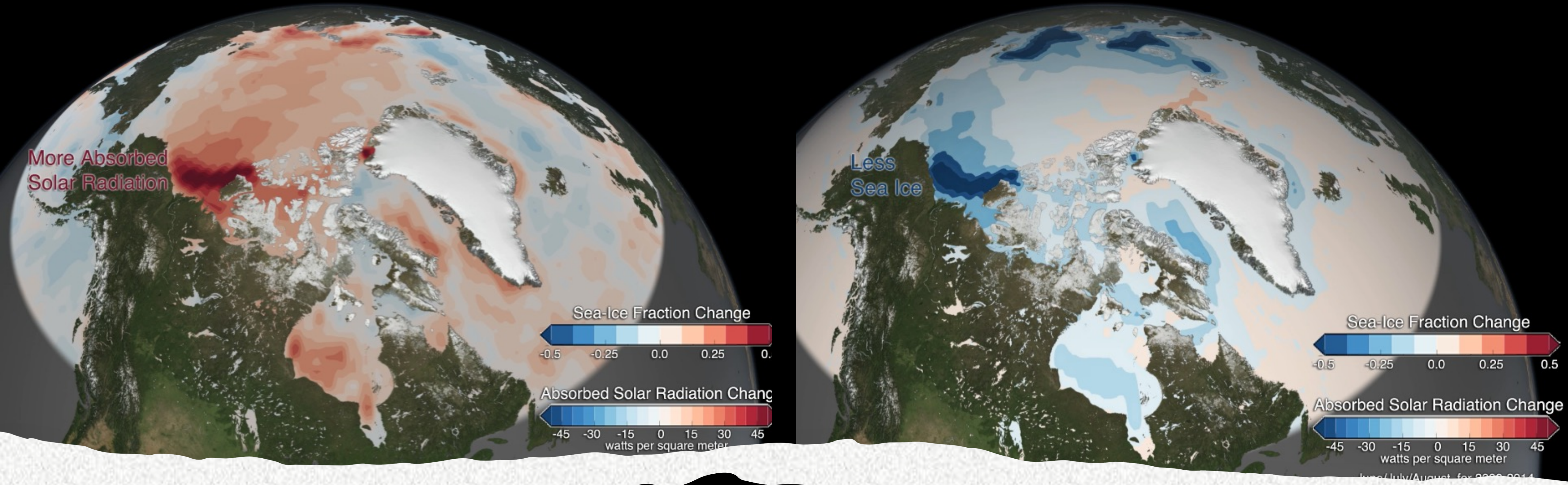

Exploring the use of CERES data for providing observational constraints on Arctic Warming

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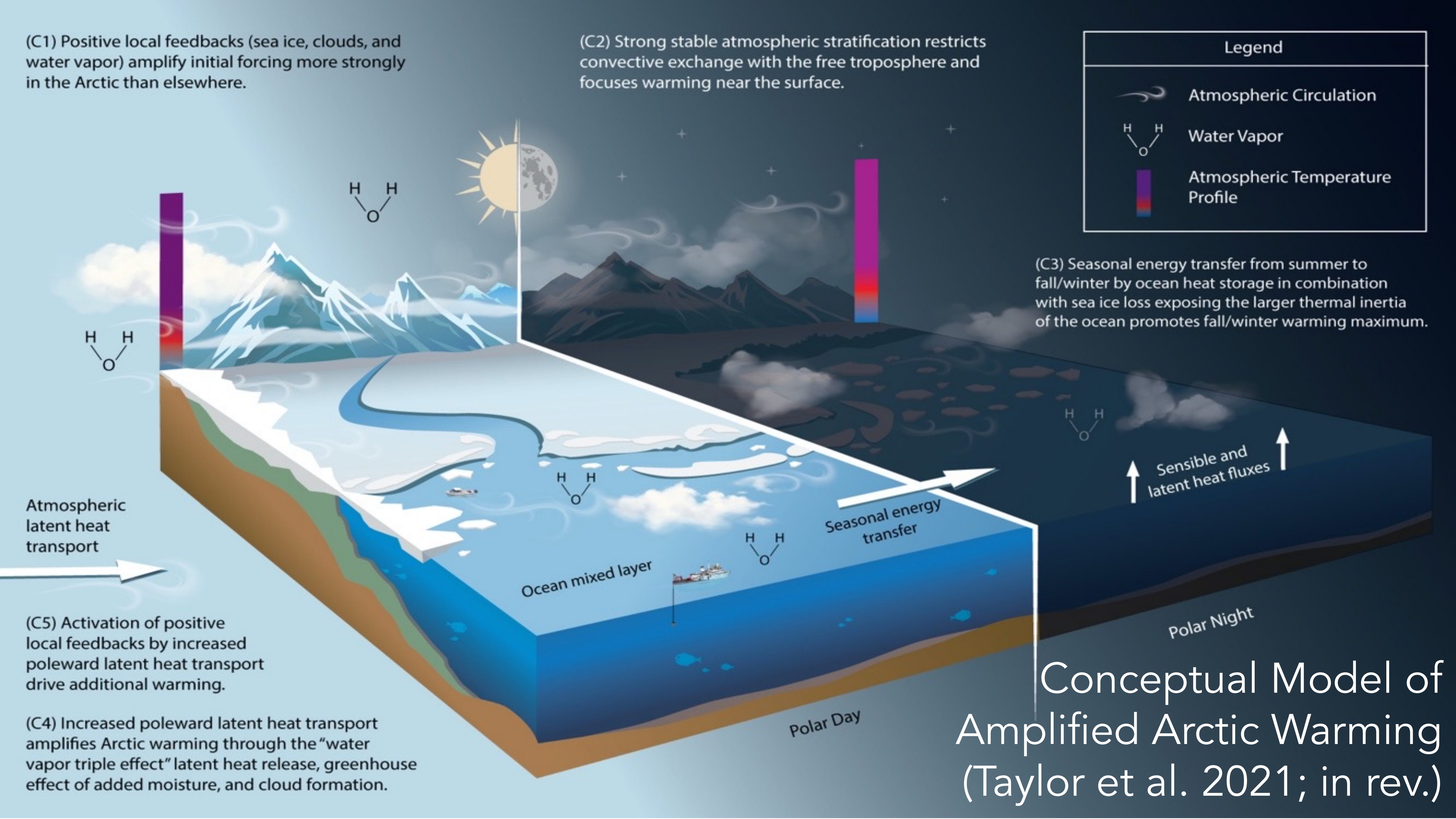
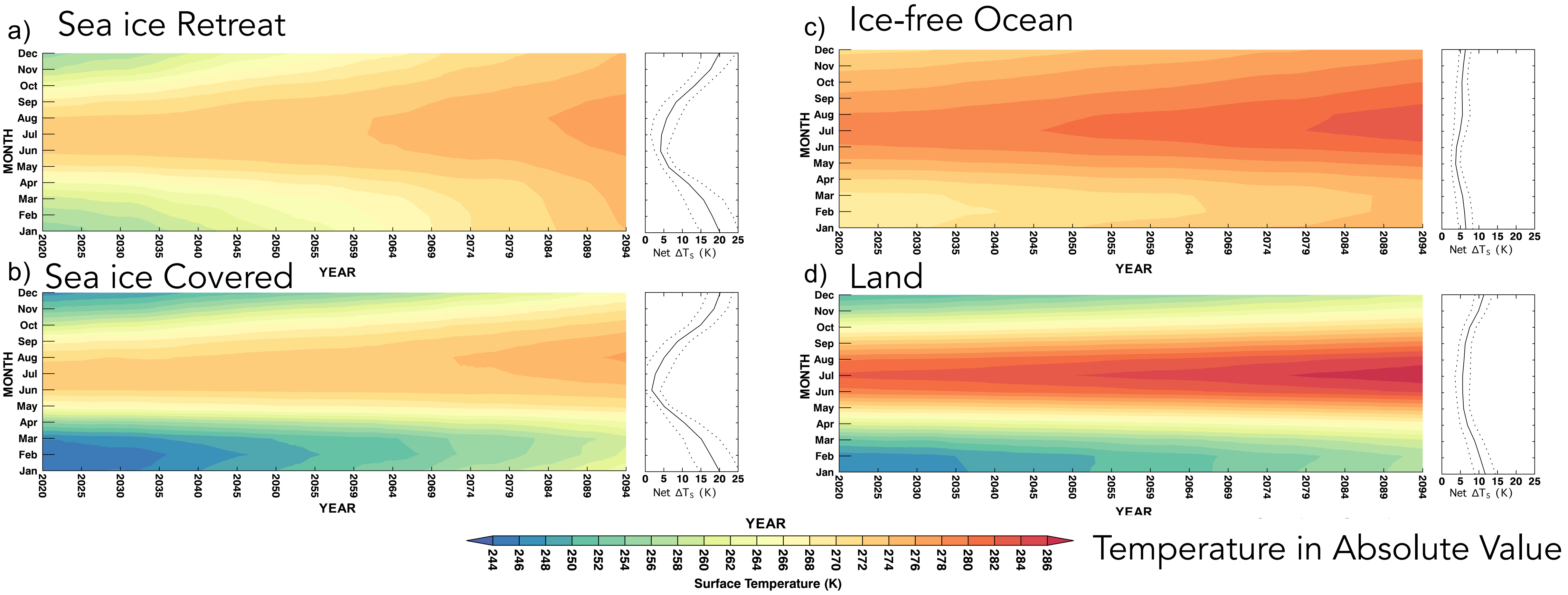
CERES 2021 Fall Science Team Meeting
October 13, 2021



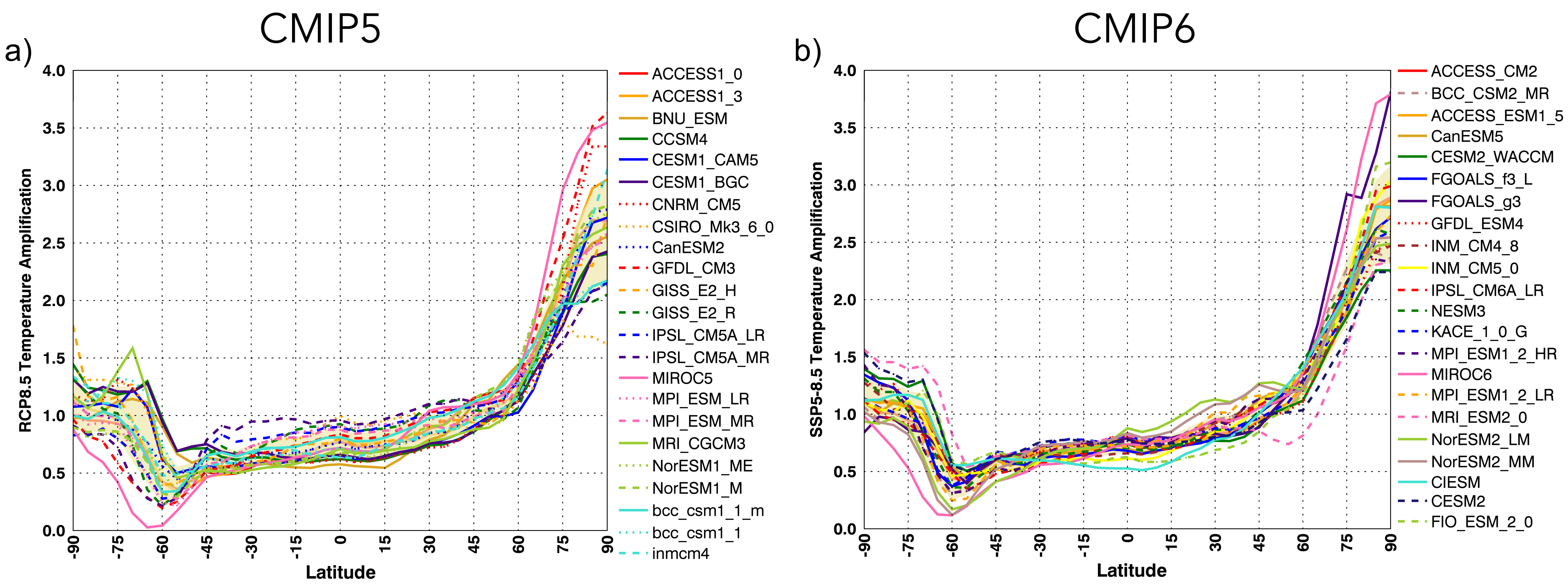
Conceptual Model of Amplified Arctic Warming (Taylor et al. 2021; in rev.)

Surface-type dependent Arctic warming response



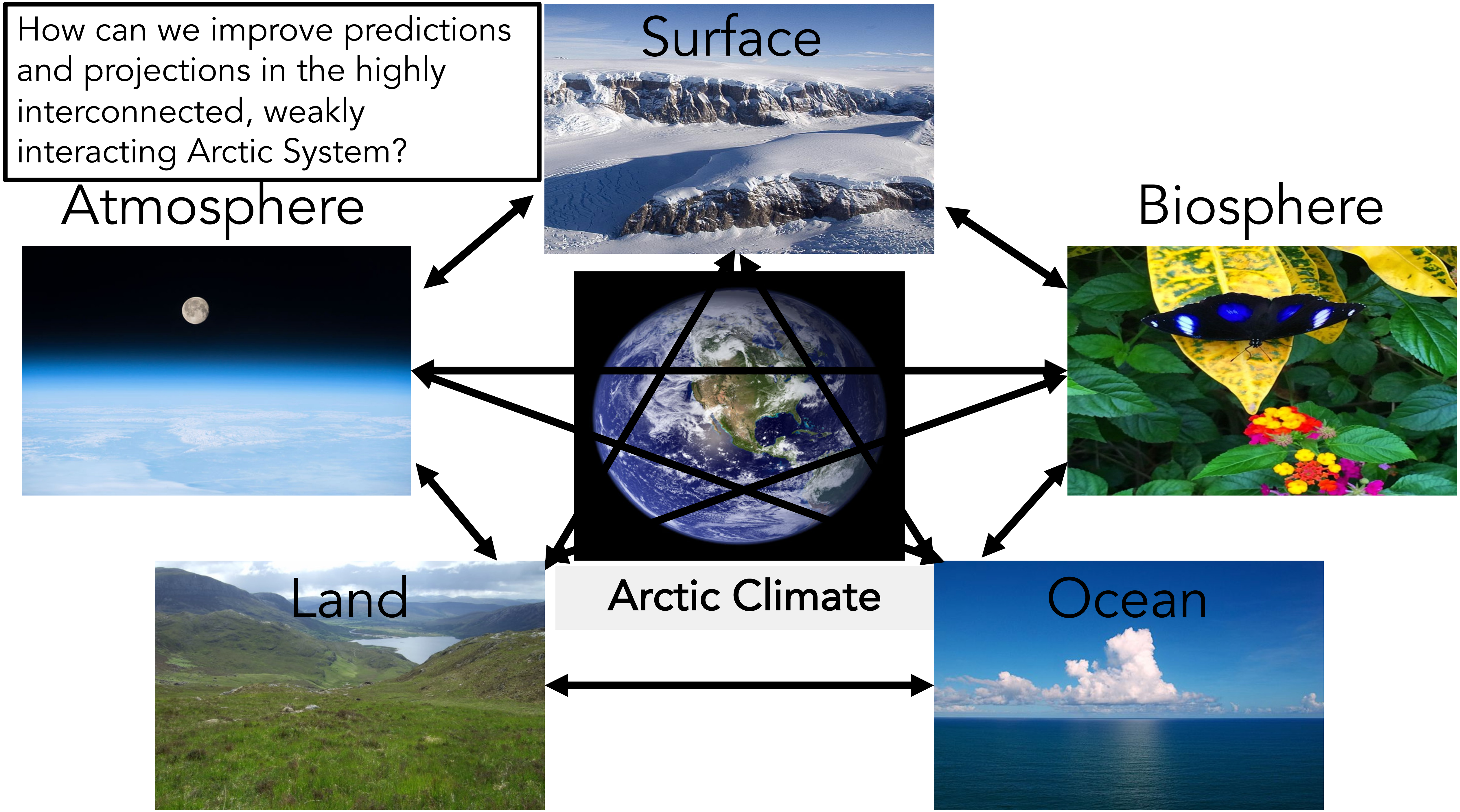
Sea ice surface warms more rapidly than other surface types suggesting that observational metrics related to sea ice should be most sensitive to changes.

Continued Uncertainty in Arctic Climate Change Projections

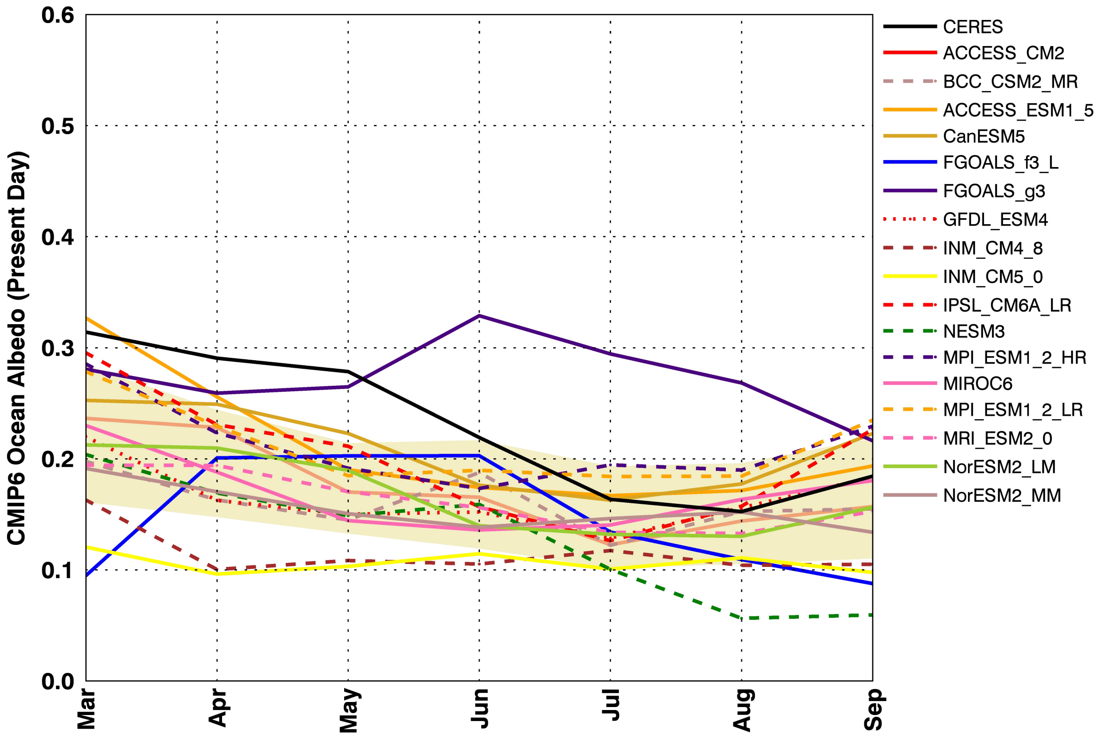


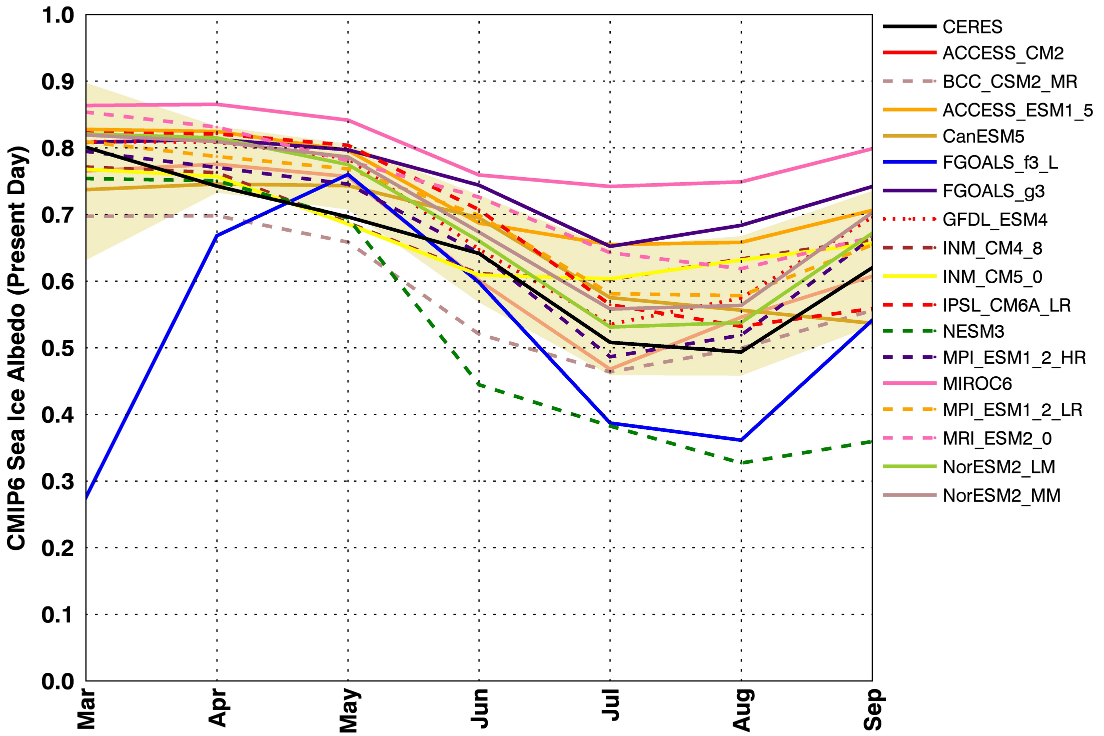
The range in the projected end-of-century Amplification of Arctic warming has changed very little between CMIP5 and CMIP6.

How can we improve predictions and projections in the highly interconnected, weakly interacting Arctic System?



CMIP6 Inter-model differences in Sea ice Characteristics

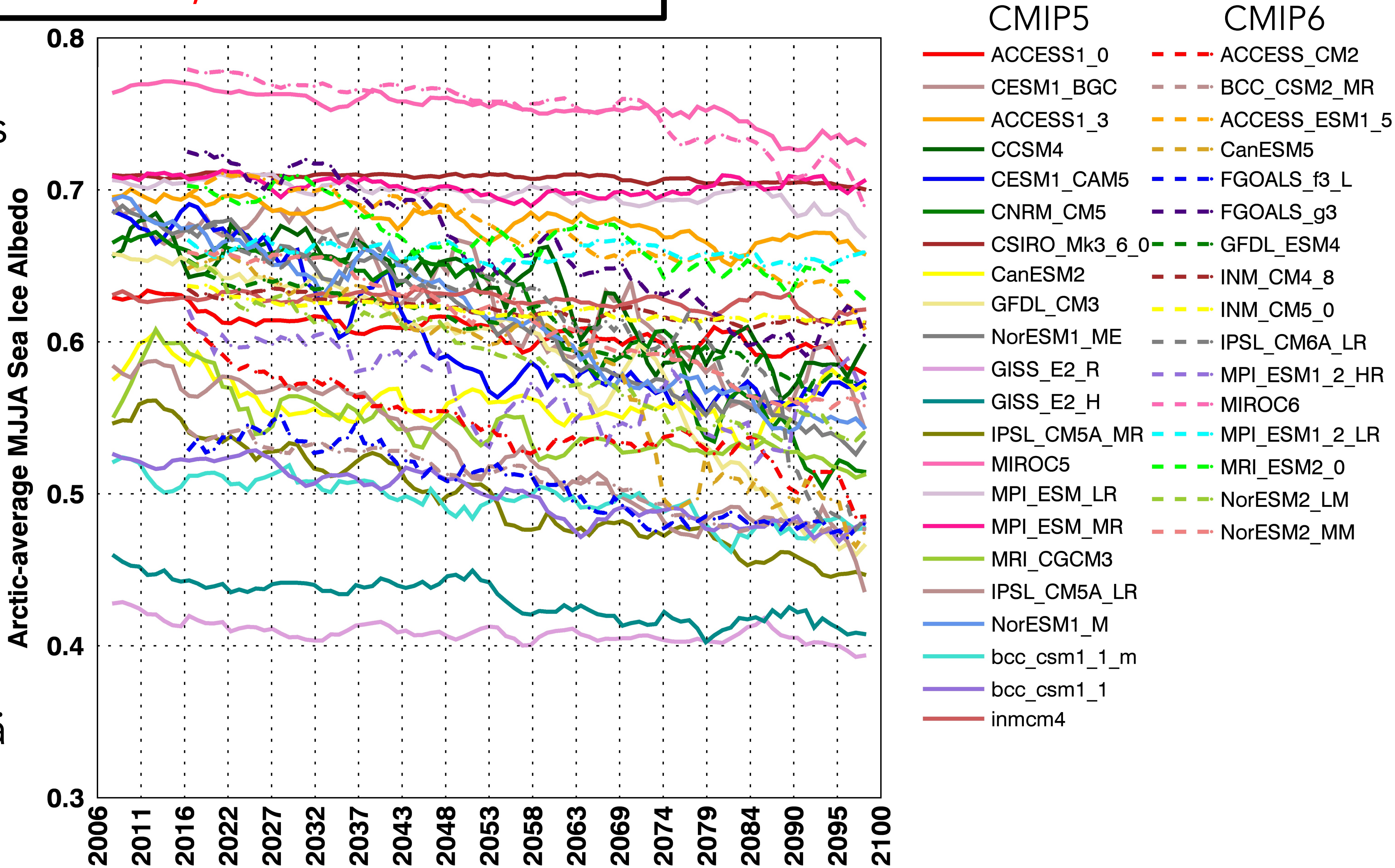




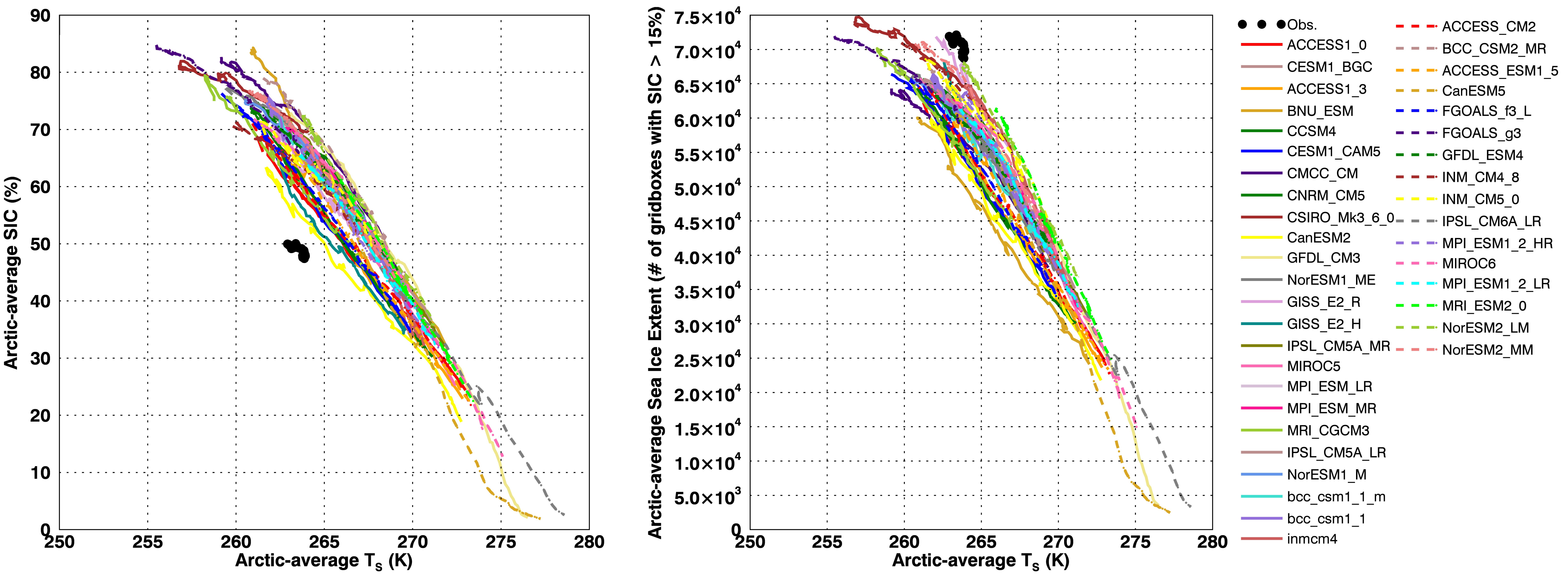
Significant inter-model spread in the surface albedo of sea ice and the ice-free ocean albedo.

Time Series of Arctic average sea ice albedo:
Some models darken sea ice, some models don't

- Model parameterizations of sea ice albedo vary such that some models allow for a change in sea ice albedo and others don't.
- Observations indicate that sea ice albedo is darkening (Riihelä et al. 2013)



Relationship between Sea ice and Arctic Surface Temperature



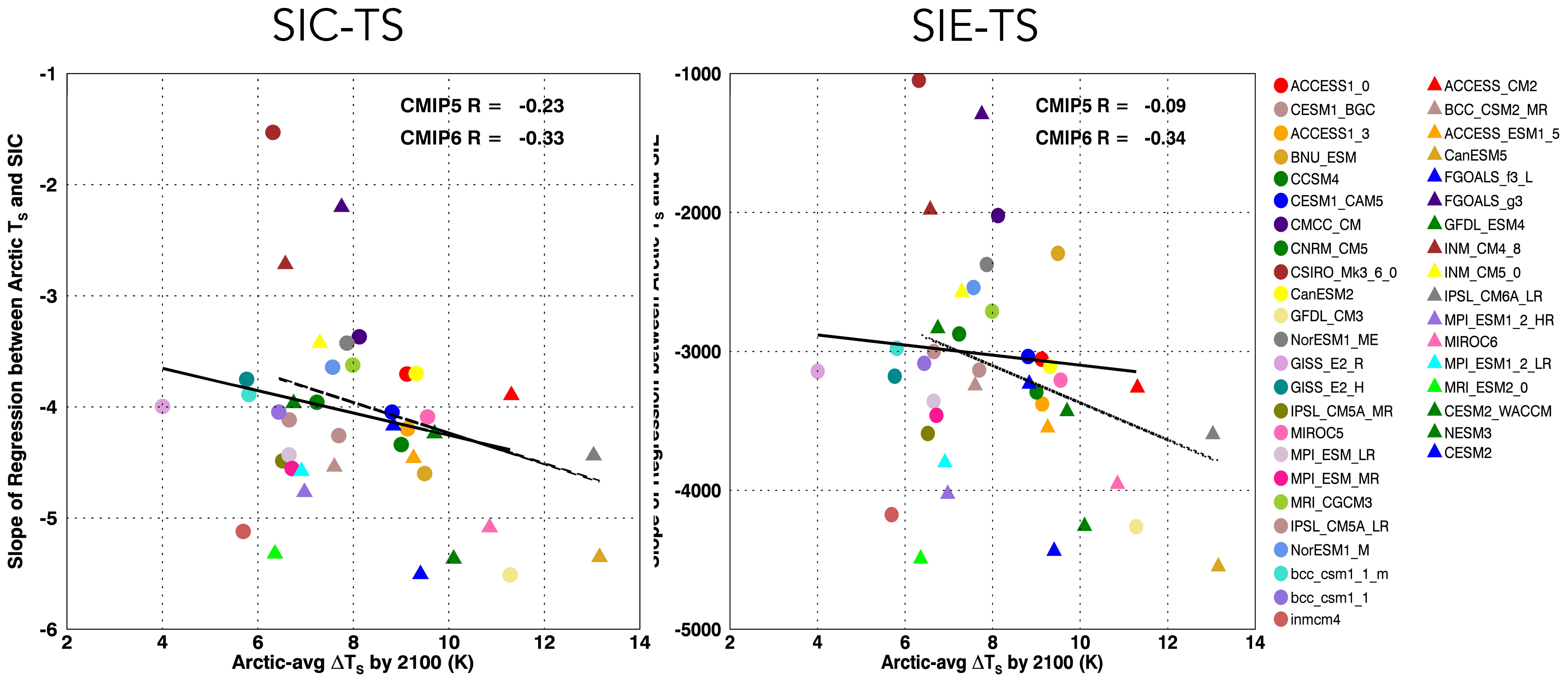
Interesting things to note:

- Models start colder than observed.
- Models start with high sea ice concentration than observed.
- Most models start with less sea ice extent than observed.

The slope of this line represents an integrative metrics of the importance of sea ice to Arctic temperature.

Influence of SIC/TS relationship and projected warming

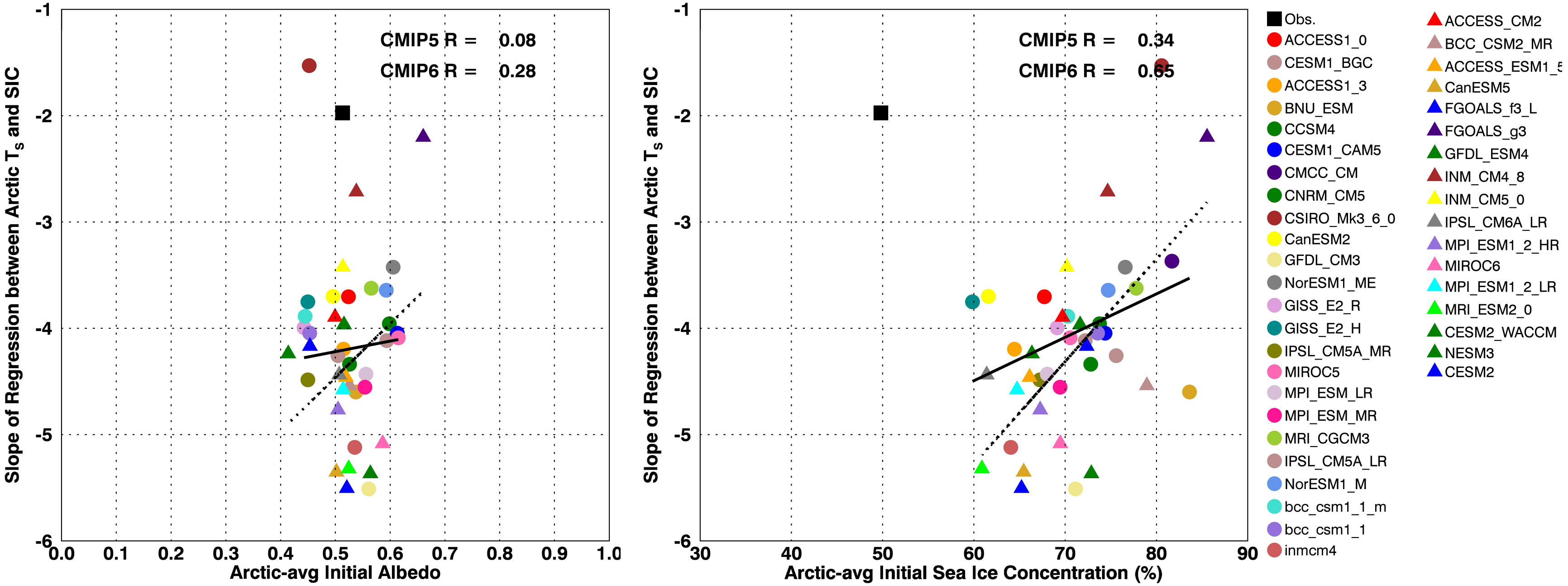
The SIC-TS and SIE-TS regression slopes do not correlate strongly with projected Arctic average warming for either CMIP5 or CMIP6

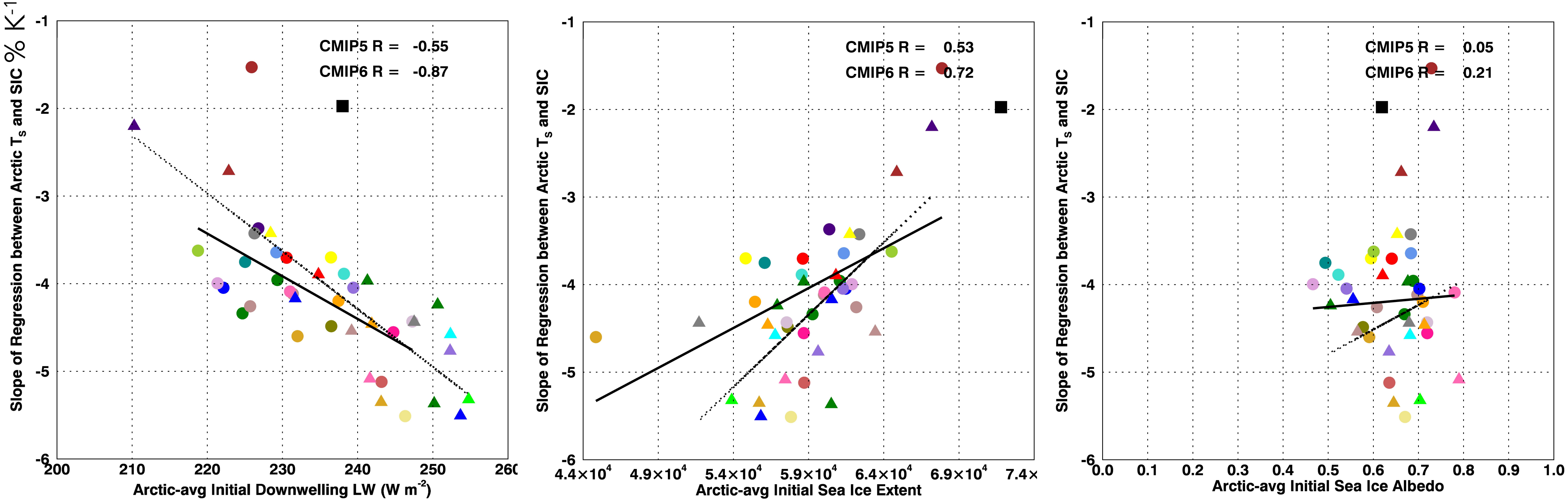


The relationship slope between SIC and TS is not a silver bullet. The next step is to understand the factors that influence the inter-model spread in this relationship.

What Factors influence the SIC/TS relationship: initial conditions?

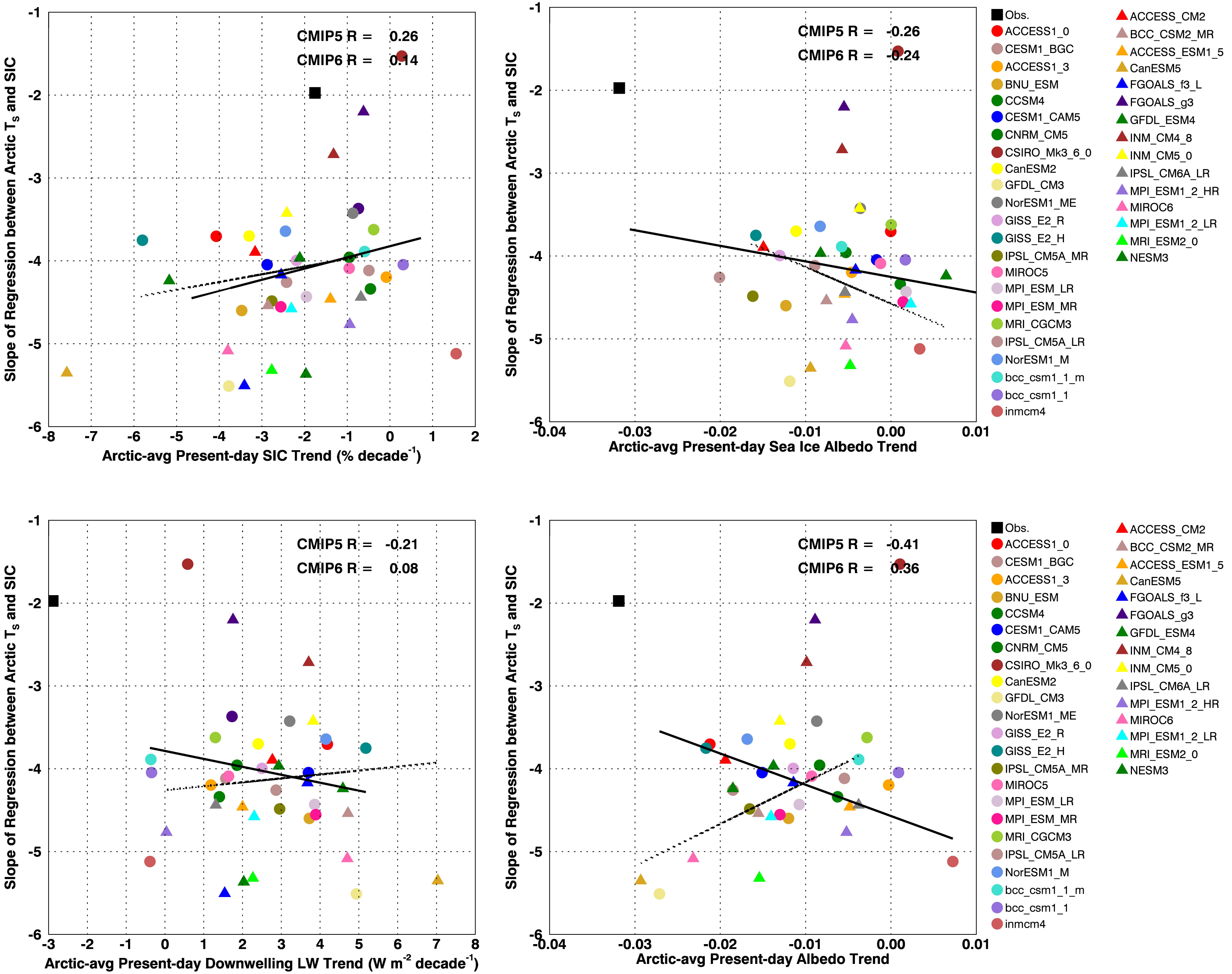
The initial (first 20-year average) sea ice concentration, sea ice extent and downwelling LW correlate strongly with the SIC/TS regression slope.





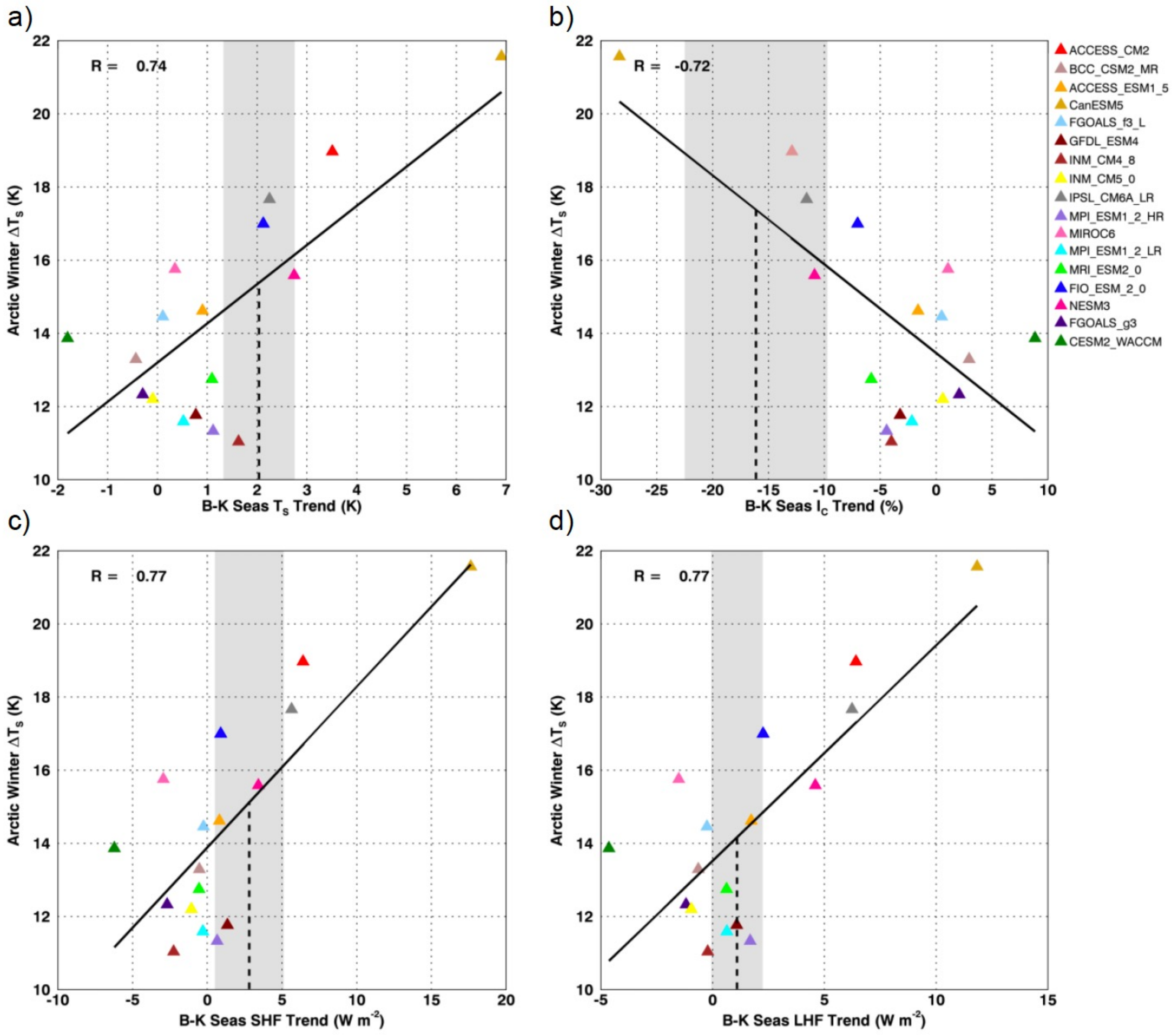
What Factors influence the SIC/TS relationship: initial trends?

Overall, the trends in these variables correspond weakly to the SIC-TS relationship.

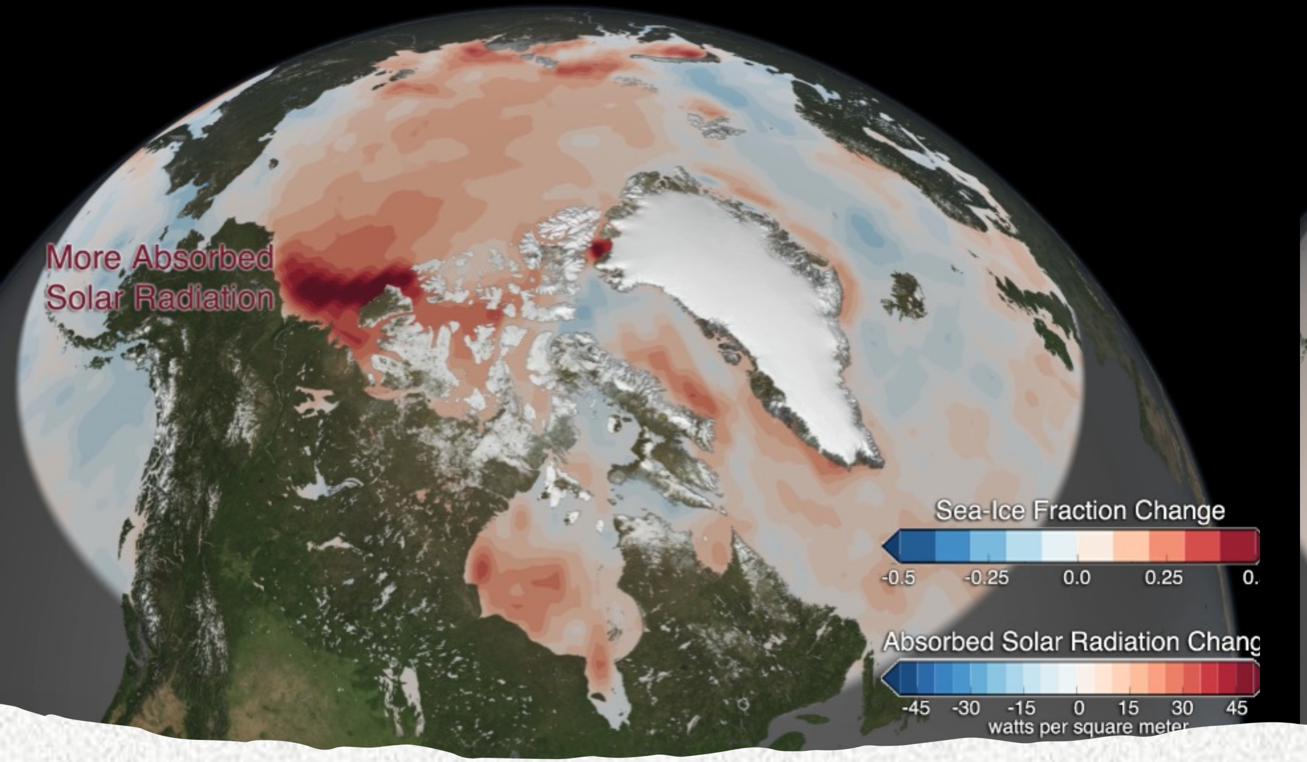


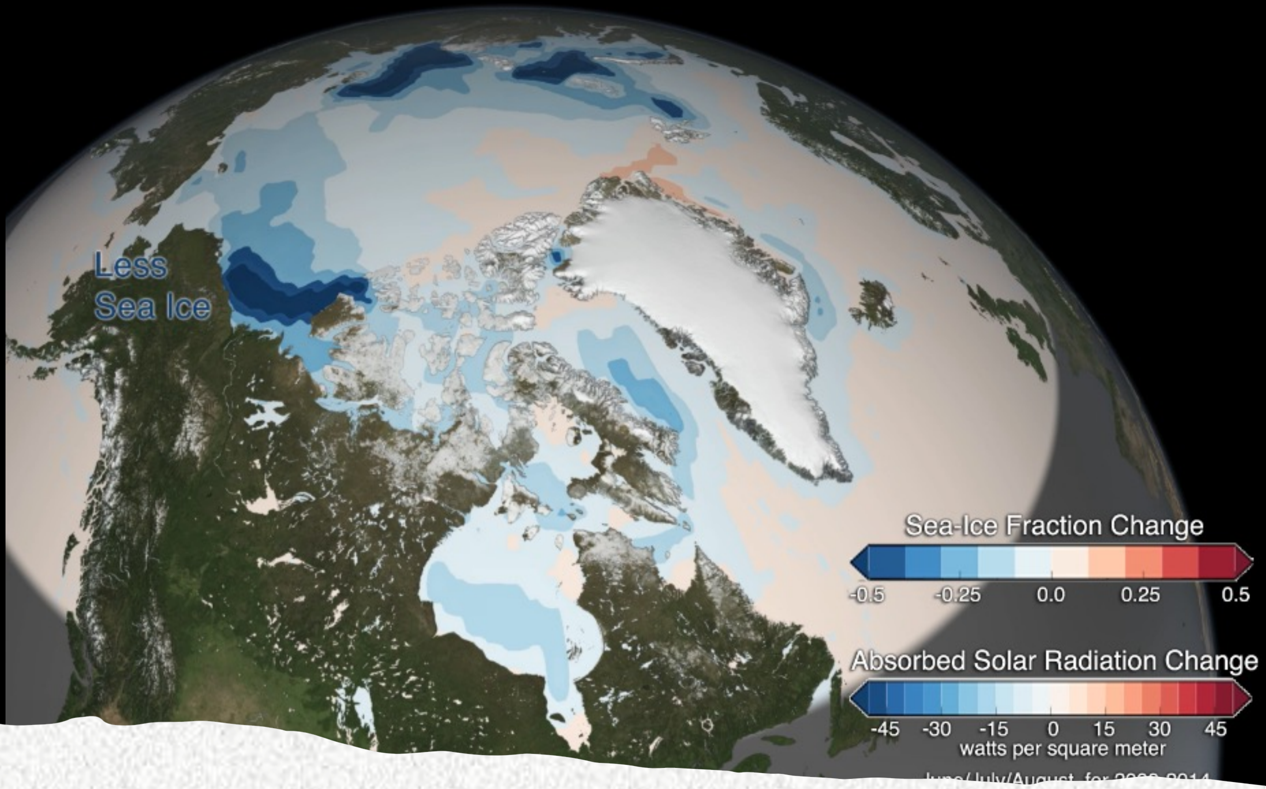
Other variables: Regional, Present-Day Surface Trends

- Leading hypotheses about the drivers of Arctic Amplification indicate that surface turbulent changes play a key role in future warming.
- Boisvert et al. (2021) explore the potential use of observed regional trends in the Barents-Kara Seas (sea ice retreat region) to constrain warming projections.
- Strong correlations are found between present-day trends and projected warming.



Regional, present-day surface energy budget trends may surface as a useful constraint on Arctic climate projections.



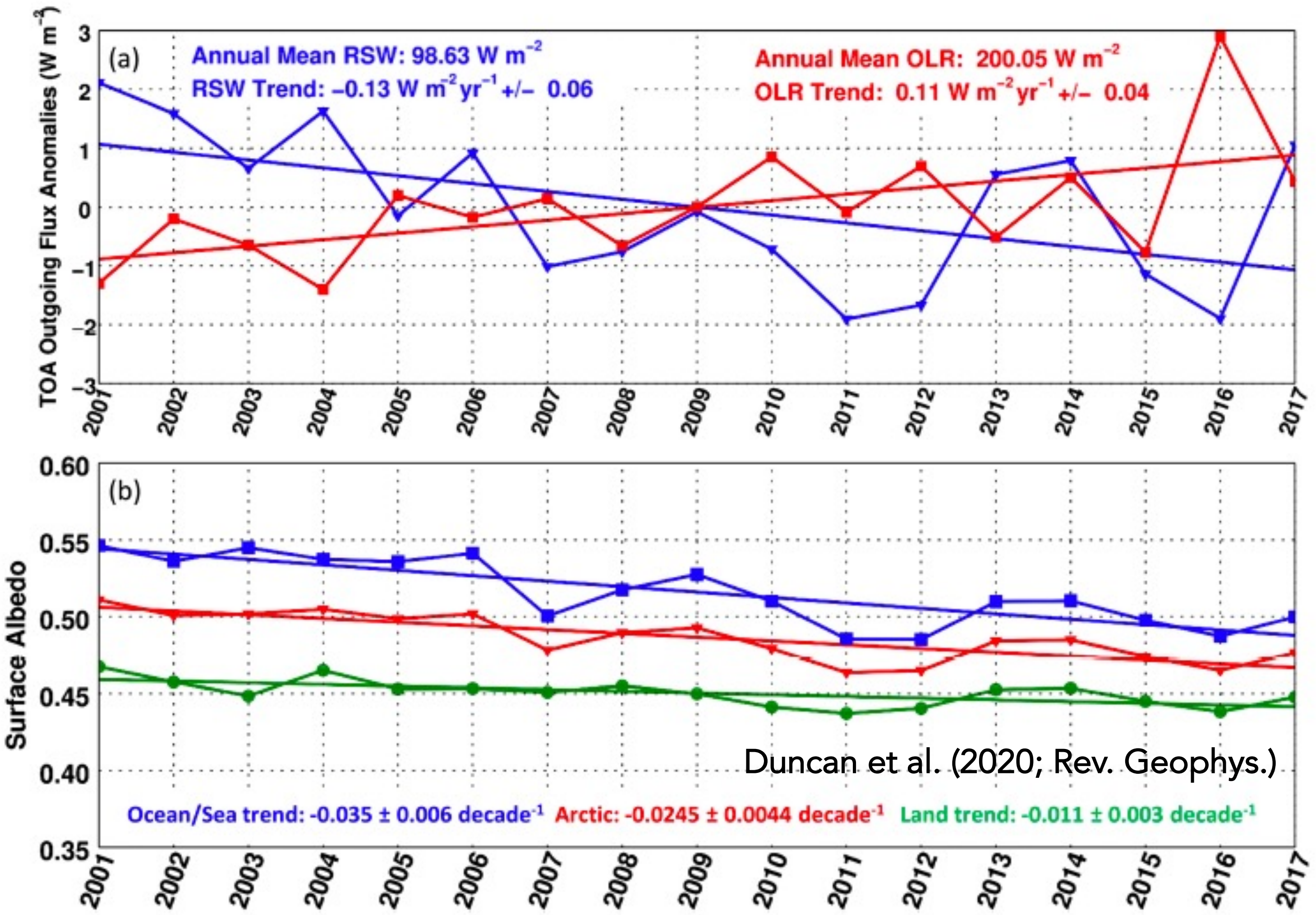


Conclusions, Takeaways, and Next Steps:

- The emergent constraint approach is needed in the Arctic to reduce uncertainty in projections at a timescale faster than the changing Arctic itself.
- There is no silver bullet for an emergent constraint in for Arctic surface temperature projections.
- CMIP5 and CMIP6 models exhibit a large spread in their sea ice albedo and its changes.
- Controlling for differences in sea ice seems critical observationally constraining Arctic climate change projections.
- Both initial sea ice conditions and surface energy budget trends show promise as approaches for providing observational constraints for Arctic climate projections.

Observed Trends in Arctic Radiation Budget: EBAF TOA and SFC

- At TOA, CERES observations indicated ~-1.3 Wm^{-2} per decade decreases in reflected SW.
- At the surface, surface albedo has decreased Arctic-wide and over the land and central Arctic Ocean.
- Central Arctic Ocean surface albedo is declining by ~-0.04 per decade.



CERES observations show a robust change in the Arctic radiative budget at TOA and the SFC.